ASAP 2001
13-14 March 2001, MIT Lincoln Laboratory, Lexington, MA, USA

Space-time adaptive FIR filtering with staggered PRI

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
14 MAR 2000	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Space-Time Adaptive FIR filtering with staggered PRI	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
Richard Klemm	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
FGAN Wachtberg, Germany	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
Defense Advanced Research Projects Agency 3701 North Fairfax Drive Arlington, VA 22203-1714	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See ADM001263 for entire Adaptive Sensor Array Processing Workshop., The original document contains color images.

14. ABSTRACT
See report.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**14**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

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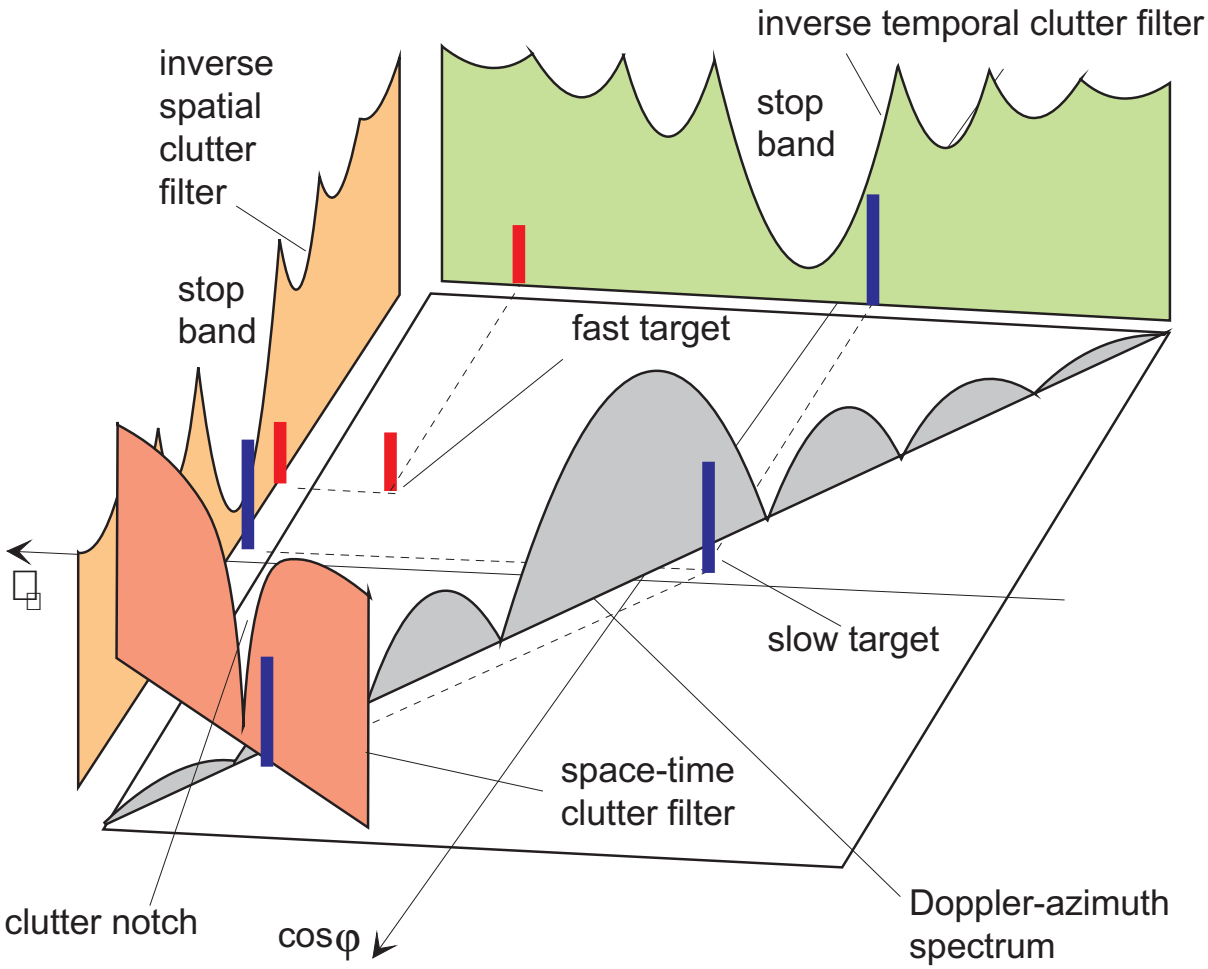

Principle of STAP

clutter spectrum | temporal filter | spatial filter | STAP

Principle of STAP

Space-time adaptive FIR filtering with staggered PRI

The optimum processor

$$\mathbf{w} = a\,\mathbf{Q}^{-1}\mathbf{s}(j,\nu)$$

$\mathbf{Q}$ space-time clutter+noise covariance matrix

$\mathbf{s}$ space-time steering vector

For large dimensions N,M not realizable by various reasons (amount of computations, lack of training data, accuracy)

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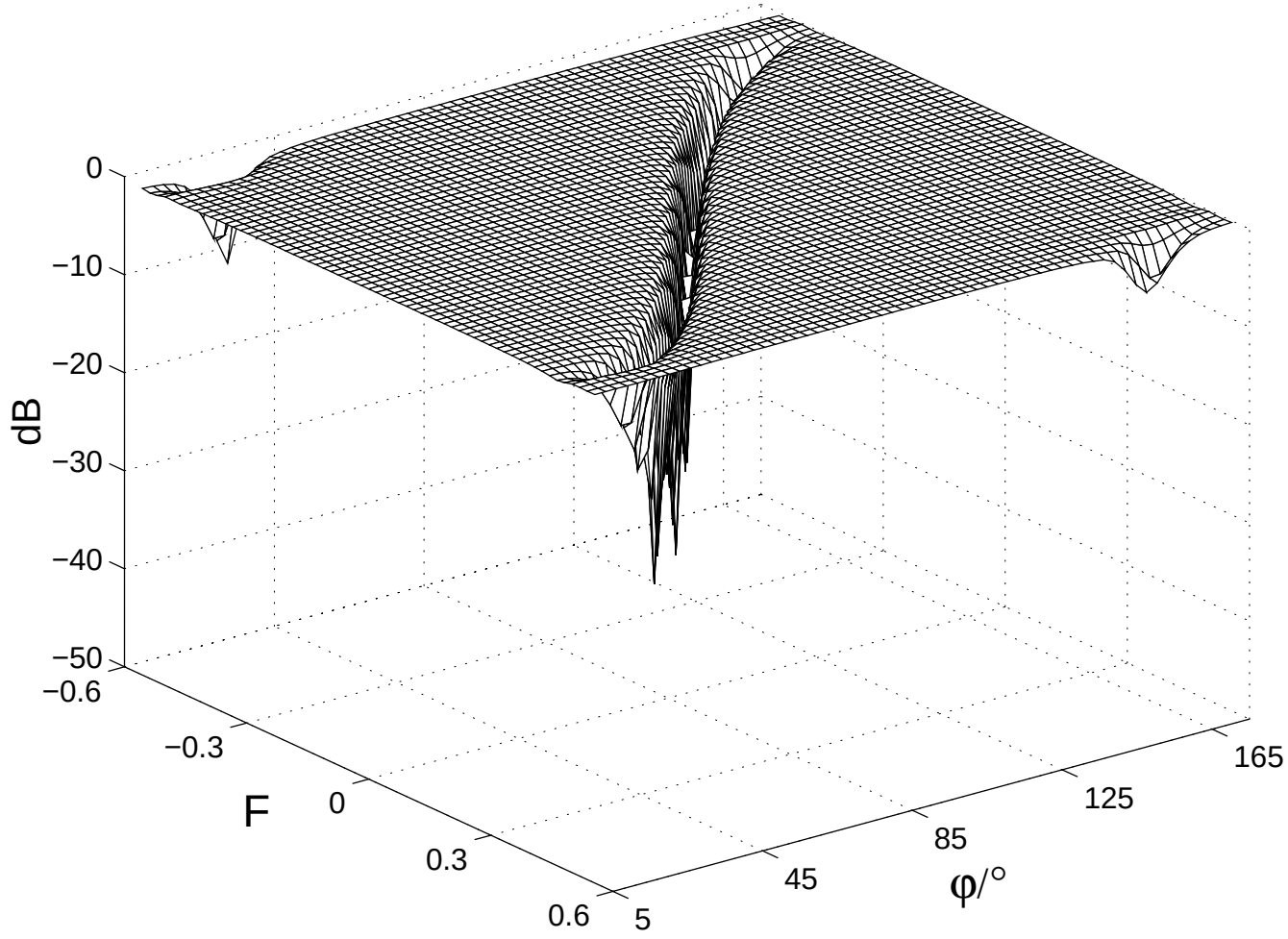
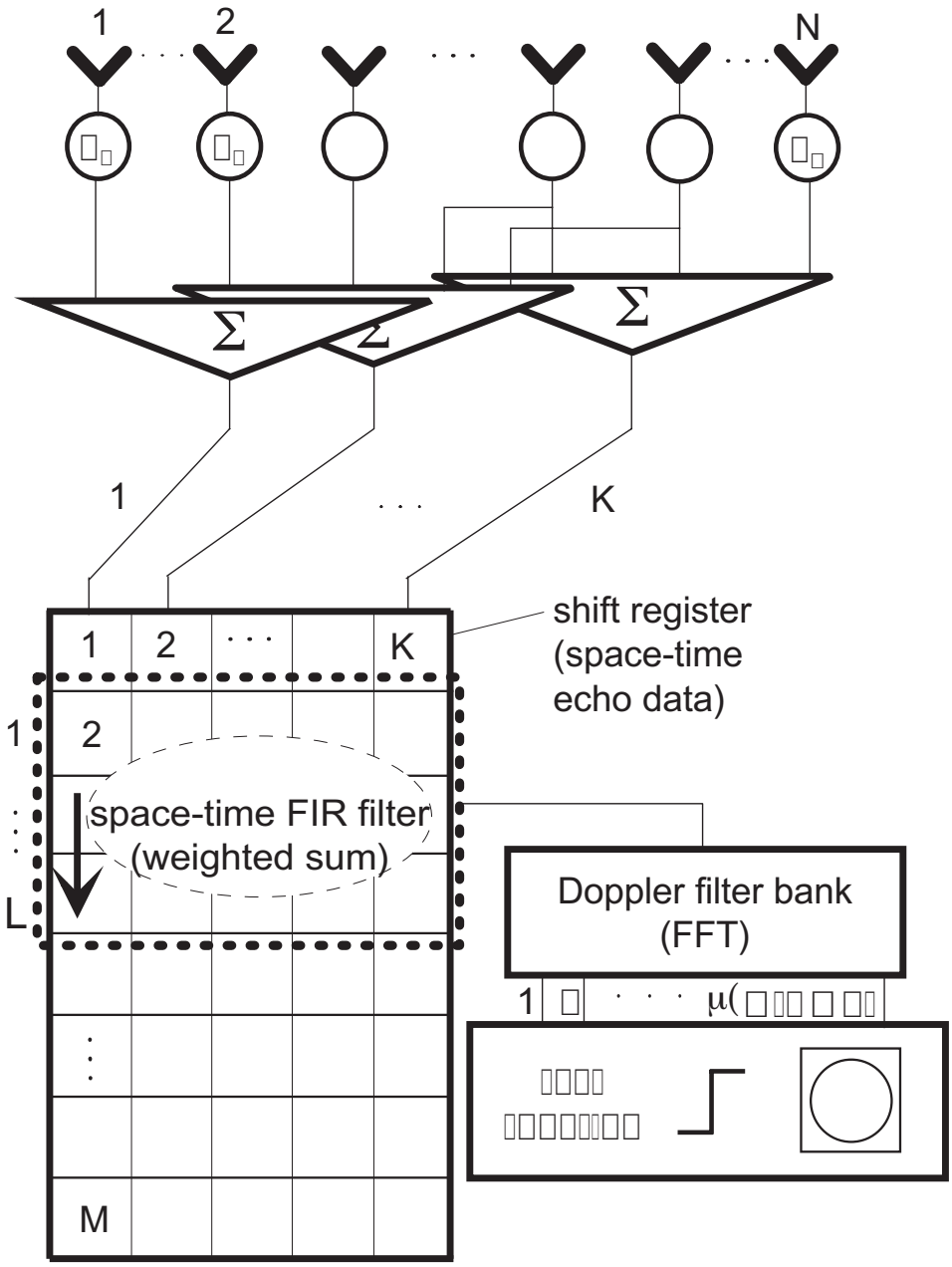


Azimuth-Doppler Characteristics of a STAP Filter for Sidelooking Array

Subspace STAP techniques

- Space-time transforms (e.g. GSC concepts)
- Spatial transforms (reduction in the spatial dimension)
- FIR filters (reduction in the temporal dimension, => very efficient solution)
- Multi-stage filters
- Frequency dependent spatial processing (for large CPI only)
- Angle-Doppler subgroups (e.g. JDL-GLRT)
- others

Space-time adaptive FIR filtering with staggered PRI



Overlapping subarray processor with space-time FIR filter

Space-time adaptive FIR filtering with staggered PRI

$$\mathbf{Q} = \begin{pmatrix} \mathbf{Q}_{11} & \mathbf{Q}_{12} & \cdots & \mathbf{Q}_{1M} \\ \mathbf{Q}_{21} & \mathbf{Q}_{22} & \cdots & \mathbf{Q}_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{Q}_{M1} & \mathbf{Q}_{M2} & \cdots & \mathbf{Q}_{MM} \end{pmatrix}$$

The space-time clutter+noise covariance matrix

$$\mathbf{K} = \mathbf{Q}^{-1} = \begin{pmatrix} \mathbf{K}_{11} & \mathbf{K}_{12} & \cdots & \mathbf{K}_{1M} \\ \mathbf{K}_{21} & \mathbf{K}_{22} & \cdots & \mathbf{K}_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{K}_{M1} & \mathbf{K}_{M2} & \cdots & \mathbf{K}_{MM} \end{pmatrix}$$

and its inverse

Space-time adaptive FIR filtering with staggered PRI

$$\mathbf{K} = \mathbf{Q}^{-1} = \begin{pmatrix} \mathbf{K}_{11} & \mathbf{K}_{12} & \cdots & \mathbf{K}_{1L} \\ \mathbf{K}_{21} & \mathbf{K}_{22} & \cdots & \mathbf{K}_{2L} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{K}_{L1} & \mathbf{K}_{L2} & \cdots & \mathbf{K}_{LL} \end{pmatrix}$$

The north-west $NL \times NL$ submatrix
(N number of antenna elements, L temporal filter length)

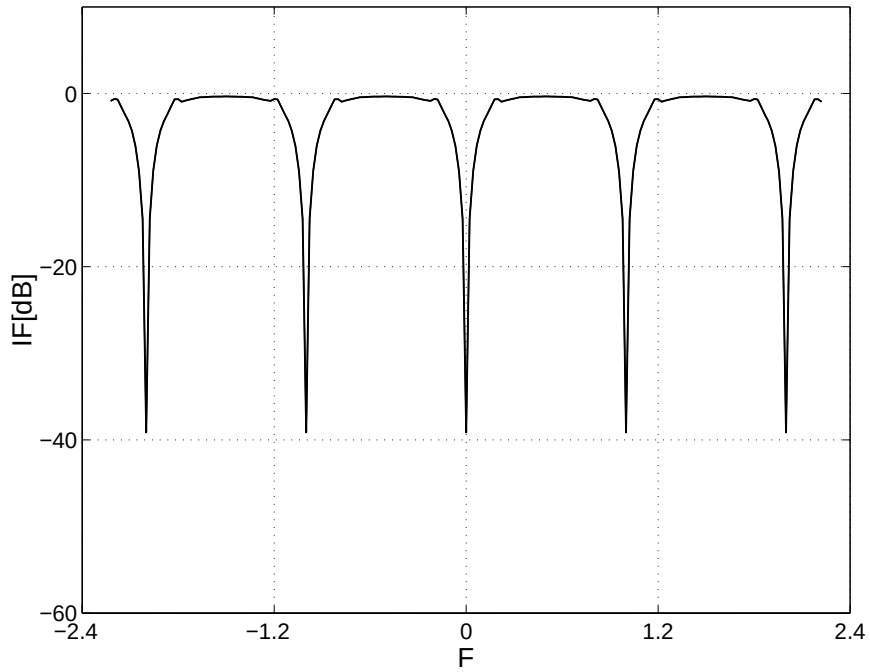
$$\tilde{\mathbf{K}} = \begin{pmatrix} \mathbf{K}_{11} \\ \mathbf{K}_{21} \\ \vdots \\ \mathbf{K}_{L1} \end{pmatrix}$$

The LS FIR filter matrix (1. Block column of inverse)

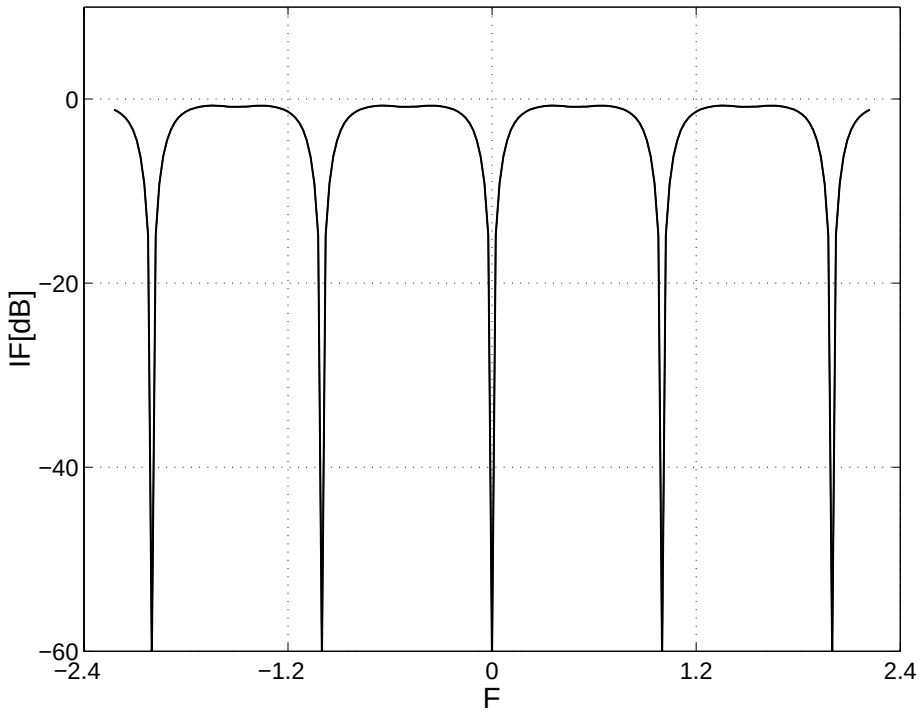
$$\mathbf{h} = \tilde{\mathbf{K}}\mathbf{b}$$

Further reduction: beamforming

Space-time adaptive FIR filtering with staggered PRI



Fully adaptive processing, constant PRI



FIR filter, 5 taps, constant PRI

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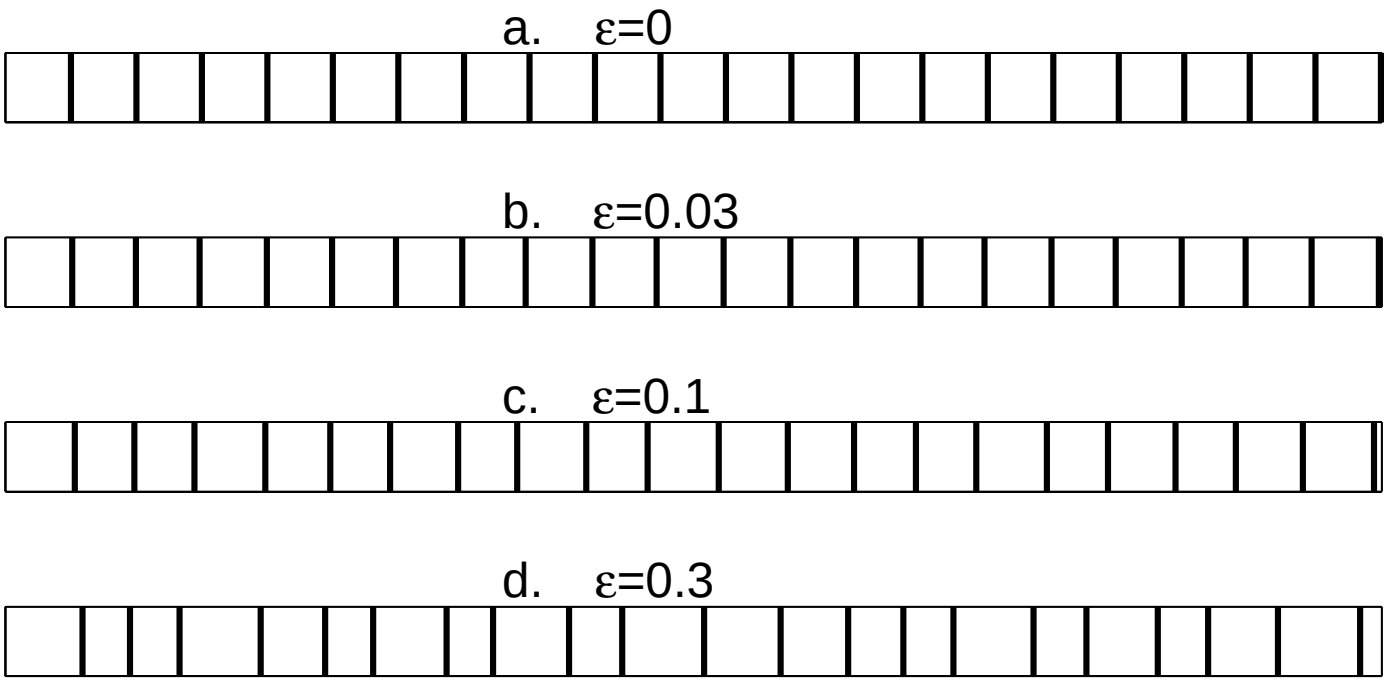

Pseudorandom PRI staggering

Properties of staggered PRI

- Avoidance of multiple clutter notches (blind velocities)
- Unambiguous target Doppler estimates
- Resistance against spot jammers
- However: no FFT for Doppler filter bank

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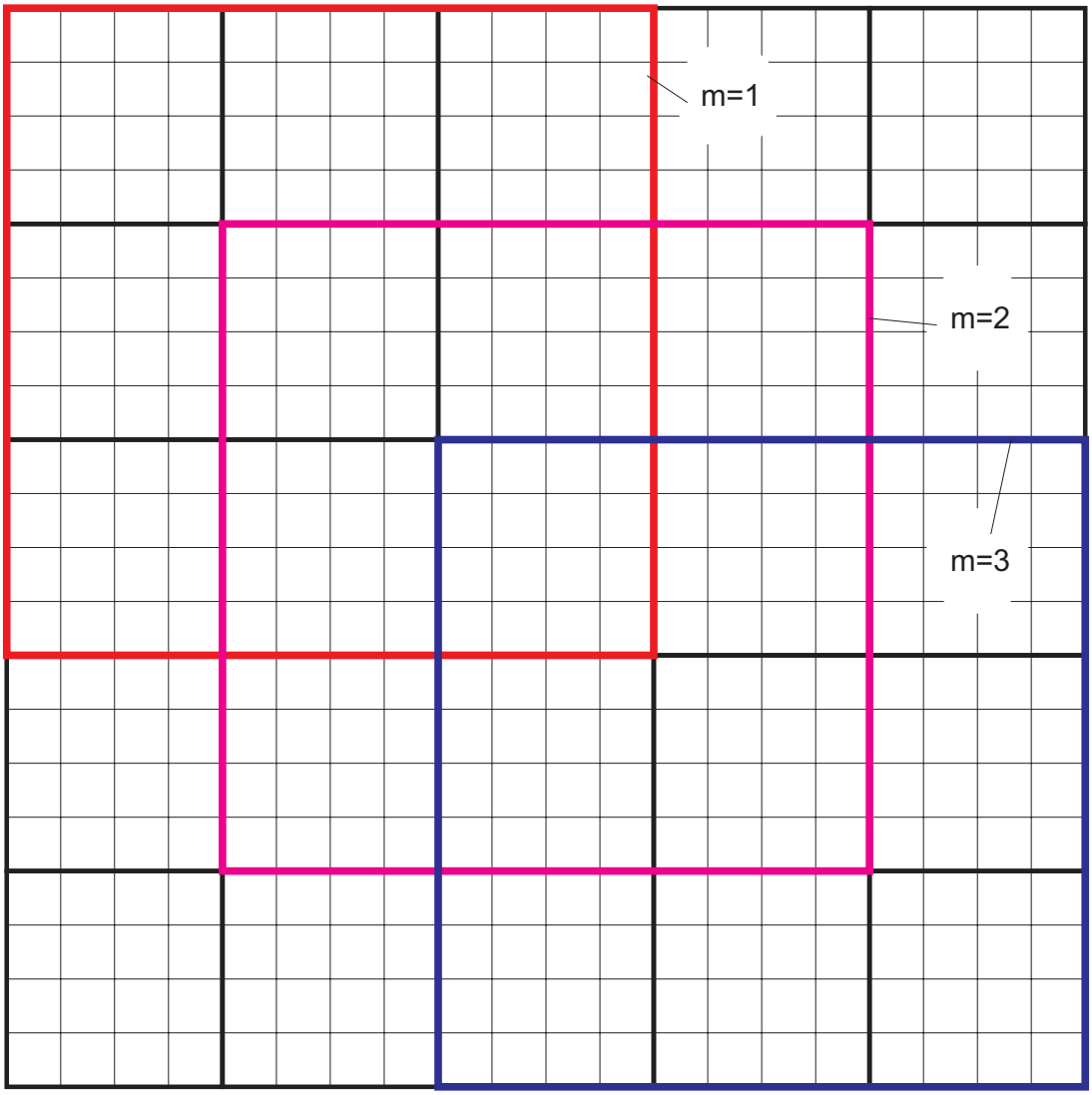

Matrix scheme for space-time FIR filtering (K=4, M=5, L=3)

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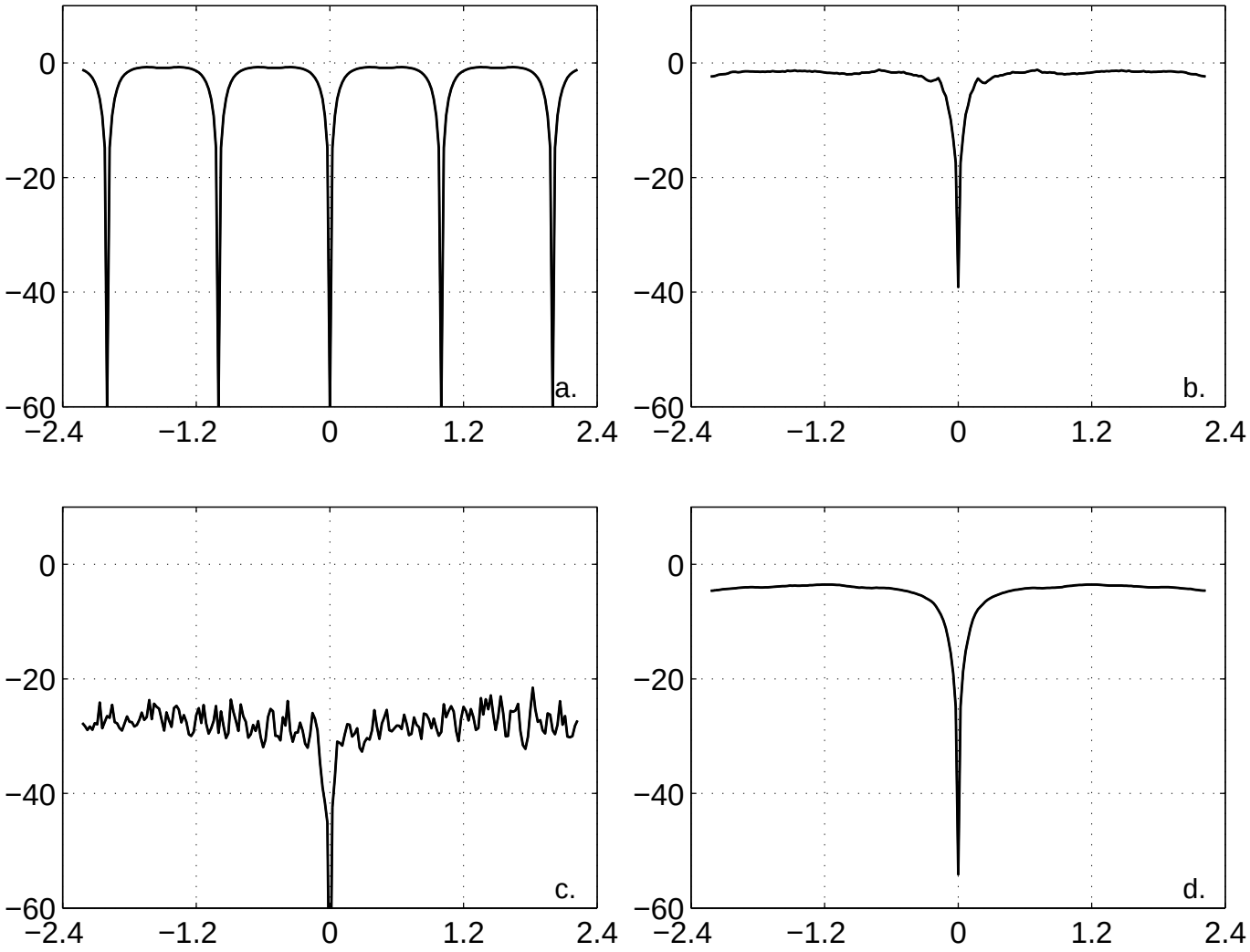

Space-time FIR filter with staggered PRI

a. optimum processing, no staggering, Nyquist sampling in space & time
b. optimum processor, staggered PRI
c. fixed ST FIR filter, staggered PRI
d. STAP FIR filter with variable coefficients

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Summary

- Staggered PRI: avoiding blind velocities (ambiguous) clutter notches, unambiguous estimation of target Doppler, resistance against spot jammers
- The optimum (LR) STAP processor can cope with staggered PRI
- The STAP FIR filter is a most efficient tool for real-time clutter rejection
- FIR filters with constant coefficients are mismatched to staggered echo sequences
- FIR filters with varying coefficients (readaption at every PRI)
- Loss compared with constant FIR filter and constant PRI: a few dB